Evaluation of AERONET AOD Measurements in the Version 3 Database

AERONET is funded by the NASA Earth Observing System project office and the Radiation Sciences Program (NASA HQ), Joint Polar Satellite System (NOAA), and large field campaigns.

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[3] Universities Space Research Association

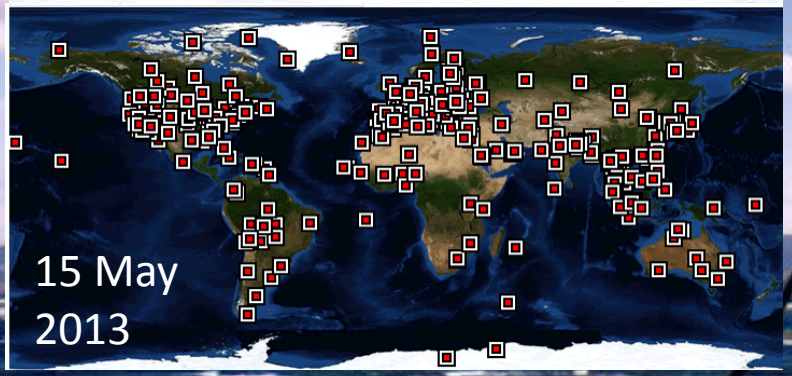
Yoram Kaufman Memorial Symposium
NASA GSFC

Outline

- Need for Higher Quality NRT AOD
- Cloud Screening
- Quality Controls
- NRT AOD Results
- Outlook and Summary

http://aeronet.gsfc.nasa.gov

AERONET Aerosol Robotic Network-Twenty Years of Observations and Research



The AERONET program is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS) and has been expanded by collaborators from international agencies, institutes, universities, individual scientists and partners.

AERONET provides a long-term, continuous public database of aerosol optical, microphysical, and radiative properties for aerosol research and characterization, validation of satellite measurements, and synergism with other databases.

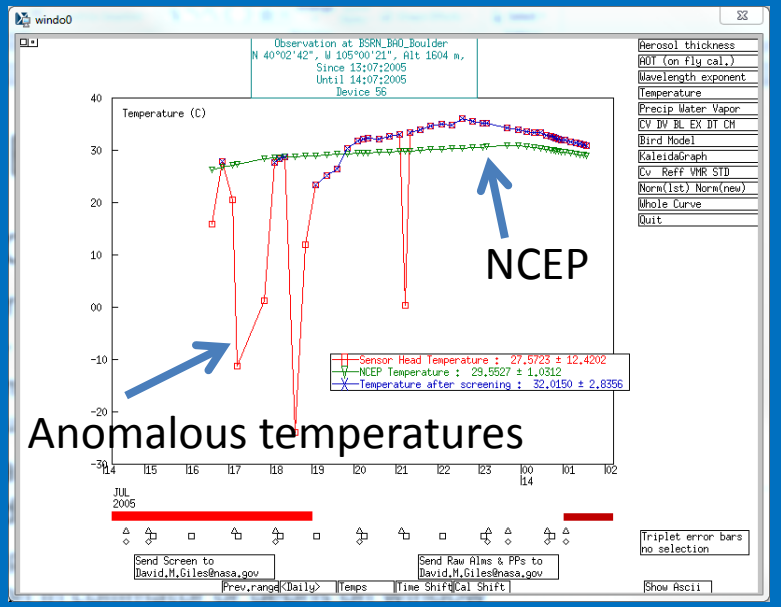
- >7000 citations
- >400 sites
- Over 80 countries
- http://aeronet.gsfc.nasa.gov

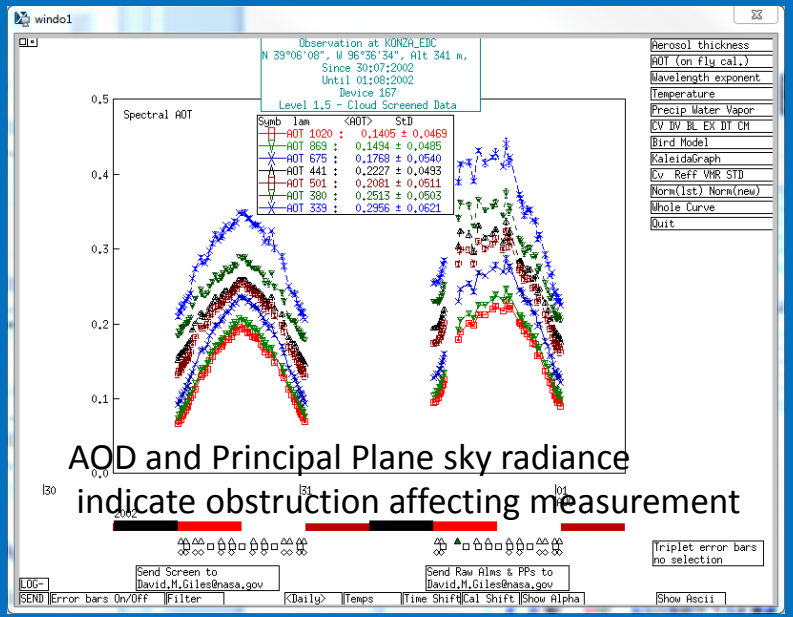
Growing Need for Higher Quality NRT AERONET Data

- Satellite evaluation
  - VIIRS, MODIS, MISR, OMI, GOES, Himawari-8, Sentinel 3, GOCI
- Data synergism
  - MPLNET, SPARTANS, GreenNet
- Aerosol forecast models and reanalysis
  - GOCART, ICAP, NAAPS, MERRA-2
- Meteorological models
  - NCEP, ECMWF, GEOS-5
- Field Campaign Support
  - KORUS-AQ, ORACLES, FIREX, CAMPex

AERONET Version 3: AOD

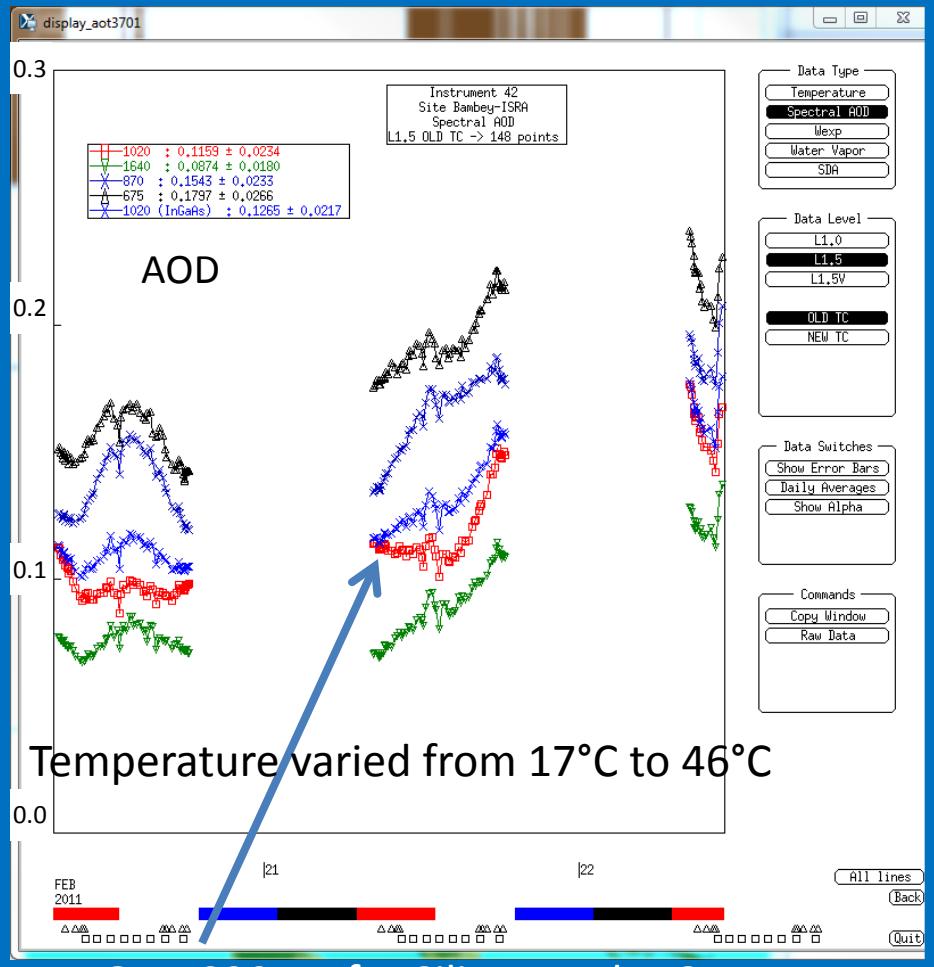
- V3 Level 1.0: Unscreened data (NRT)
  - **Applies new temperature characterizations**
  - Applies NO2 OMI L3 climatology (2004-2013)
- **V3 Level 1.5: Based on Level 1.0 and uses new automatic quality controls (NRT)**
  - **Cloud Screening**
    - **Improves removal of optically thin cirrus contamination**
    - **Preserves more highly variable smoke**
    - **Compares well to Version 2 Level 2**
  - **Quality Controls**
    - **Removes sensor temperature artifacts**
    - **Removes AOD affected by solar eclipses**
    - **Removes AOD impacted by window obstructions**
    - **Removes AOD with poor spectral dependence**
- V3 Level 2.0: Based on Level 1.5 with pre- and post-calibration applied and minimal manual intervention
  - Significantly improves timeliness of Level 2.0 data availability
  - Applies more objective removal scheme
  - Requires minimal manual analysis to remove uncommon data anomalies





AERONET V3: Spectral Temperature Characterization

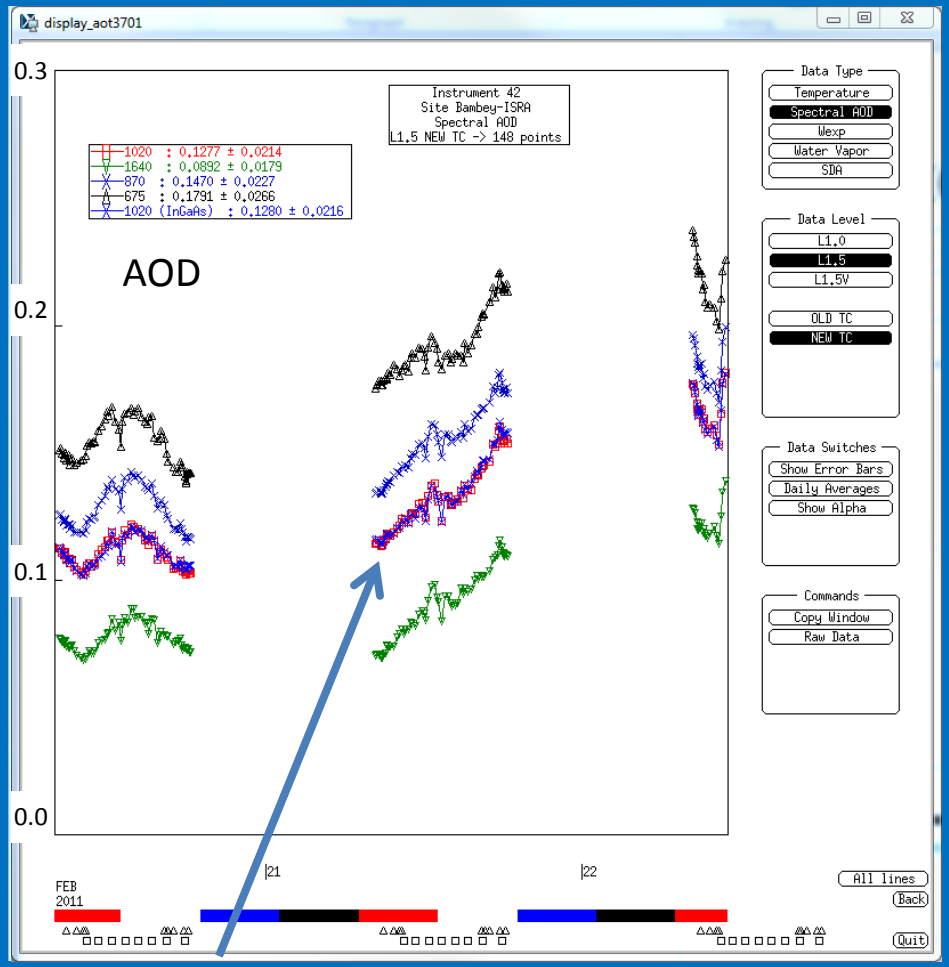
V2 Temperature Correction



Temperature varied from 17°C to 46°C

AOD 1020nm for Silicon and InGaAs detectors do not match

V3 Temperature Correction



AOD 1020nm Silicon matches 1020nm InGaAs after V3 temperature correction

V2 vs. V3 Cloud Screening

Algorithm/Parameter	Version 2	Version 3
Air Mass Range	5 to 5	7 to 7
Remaining Measurements	N < 3, reject day	After all checks applied, reject day if N_{remain} < MAX {3 or <10% of N}
Low Count Restoration	N/A	If Digital Count<5, τ870nm >0.5, α675-1020nm>1.2 or α870-1020nm>1.3, then restore measurement for evaluation
Triplet Criterion	All λs; AOD range > MAX {0.02 or $0.03*\tau_a$}	λ=675,870,1020nm AOD range > MAX{0.01 or $0.015*\tau_a$}
AOD Stability Check	Same as V3	Daily Averaged AOD 500nm (or 440nm) has σ less than 0.015, then do not perform **3-Sigma Check**
3-Sigma Check	Same as V3	AOD 500nm and α440-870nm should be within MEAN ± 3σ; otherwise reject point(s)

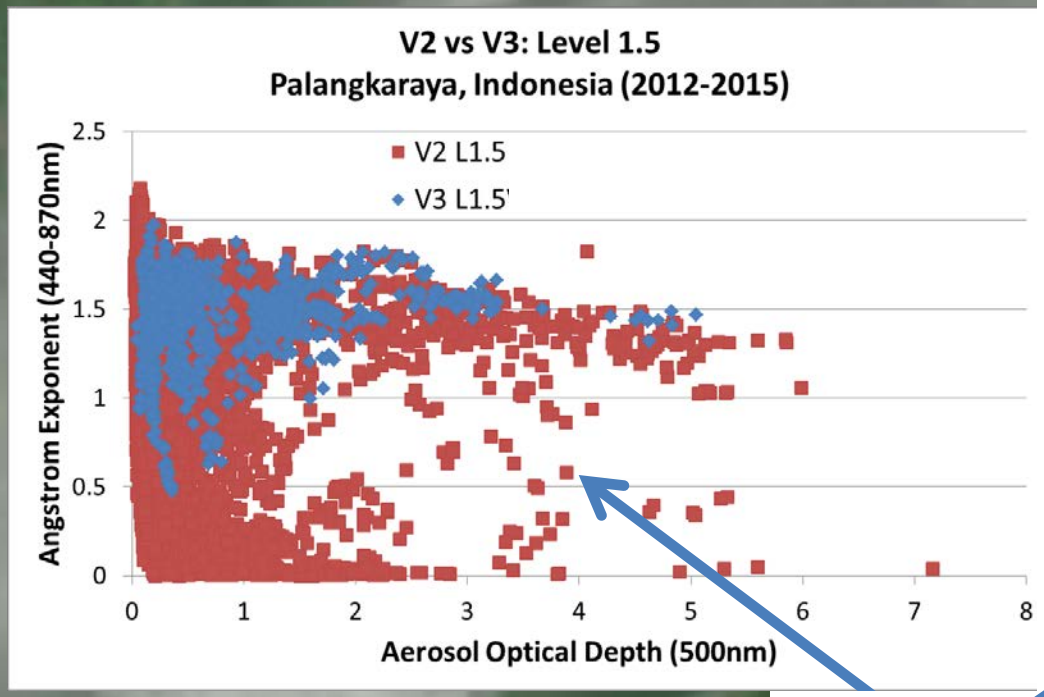
V2 vs. V3 Cloud Screening

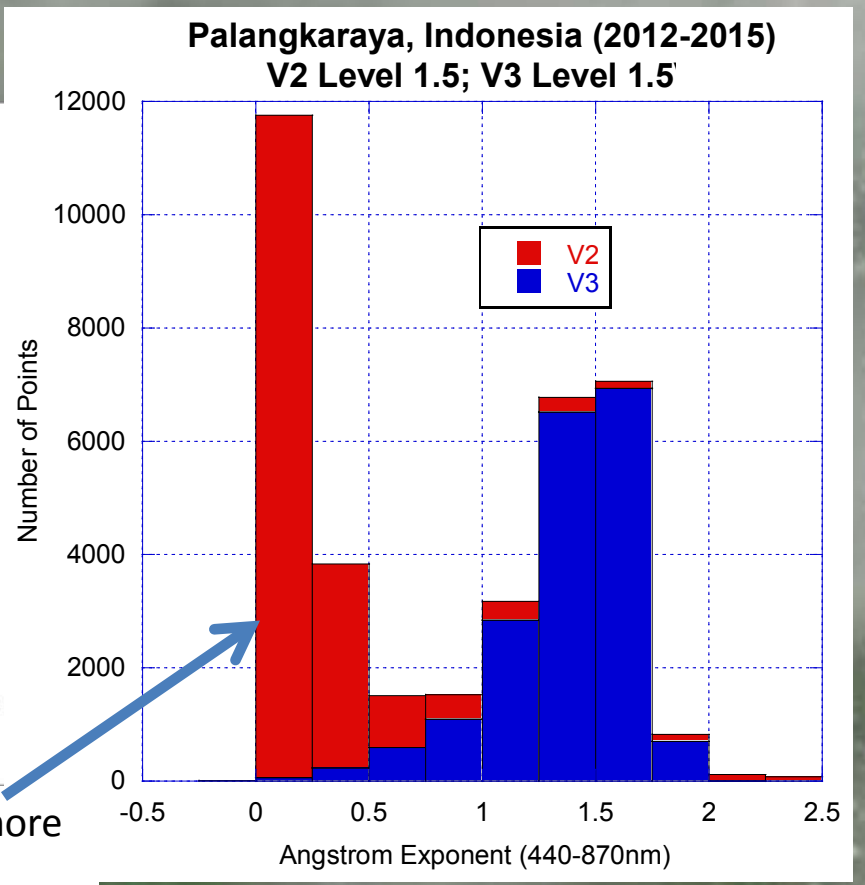
Algorithm/Parameter	Version 2	Version 3
Smoothness Check	D<16	For AOD 500nm (or 440nm) $\Delta\tau_a > 0.01$ per minute, remove larger τ_a in pair
Standalone Points	N/A	No data ±1 hour of point, then reject it unless α440-870nm > 1.0, then keep point
Solar Aureole Radiance Curvature Check	N/A	Compute curvature (**k**) for 1020nm aureole radiances from 3.2°-6.0° **ϕ**. If **k**< 2.0E-5, compute a slope of ln **k** vs ln **ϕ**. If slope is greater than 4.3 (empirically derived), then point is "cloud contaminated." For ALM, PP, and HYB, all τ_a points will be removed in the ±30 minutes period from sky measurement.
Low Count Restoration	N/A	If Digital Count<5, τ870nm >0.5, α675-1020nm>1.2 or α870-1020nm>1.3, then restore measurement for evaluation
Very High AOD Restoration	N/A	τ870 >0.5; α675-1020>1.2 or α870-1020>1.3, restore if eliminated by cloud screening

Algorithm Step Change Summary: 2 same, 4 modified, and 5 new

AERONET V3 L1.5 (Cloud Screening Only)

Palangkaraya

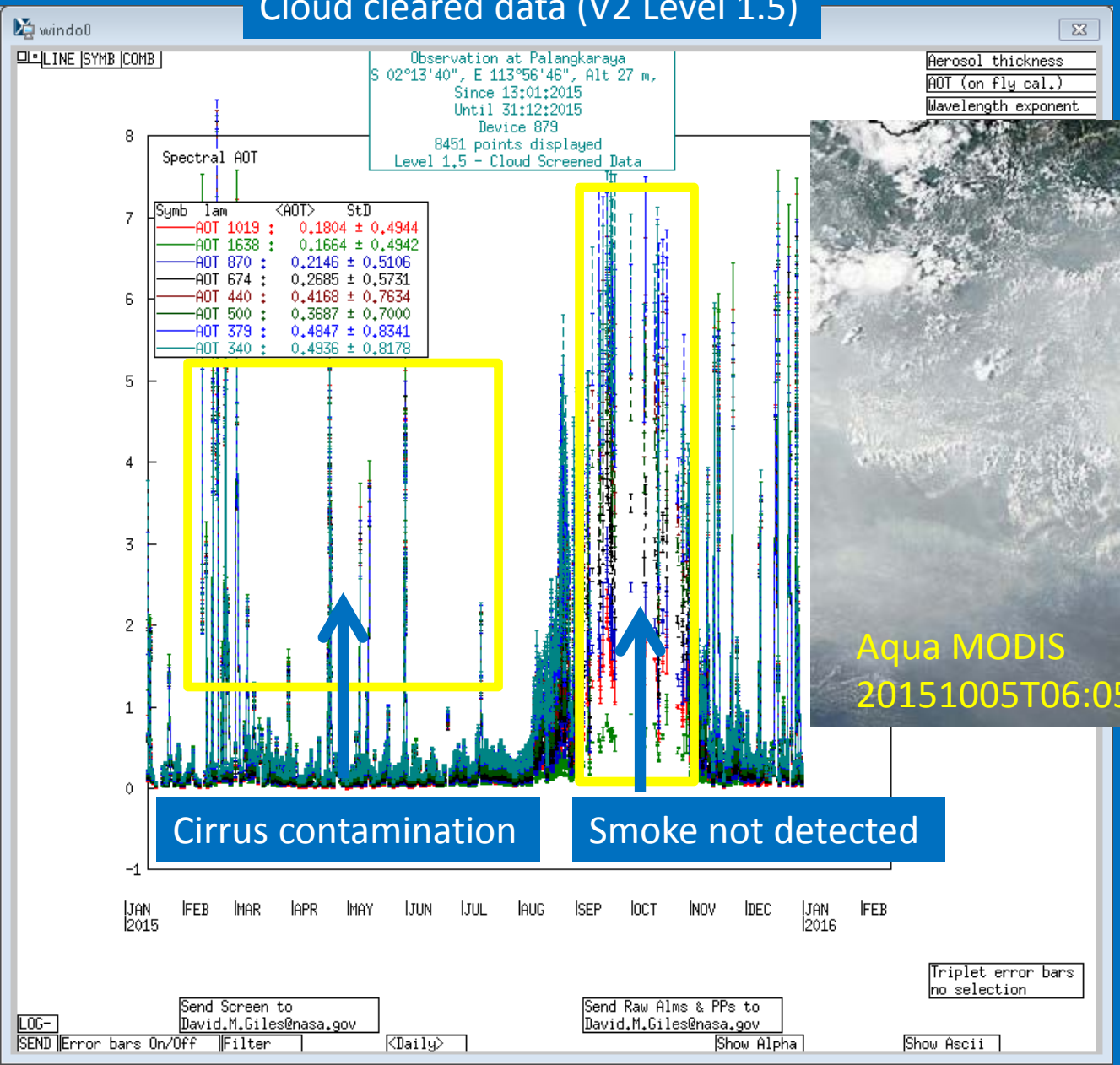


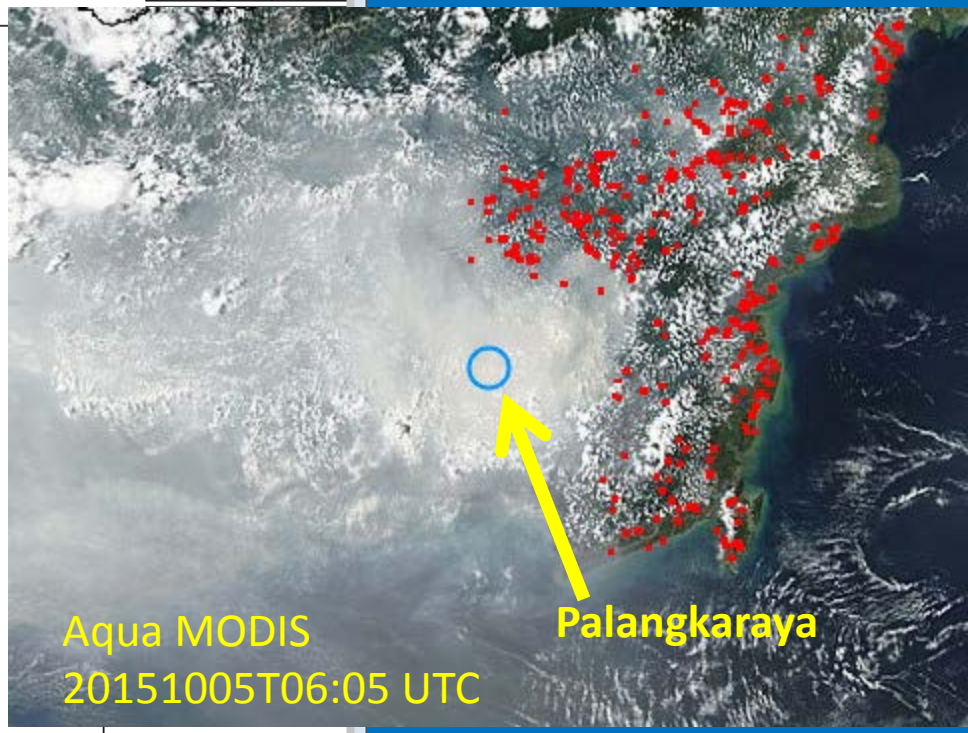


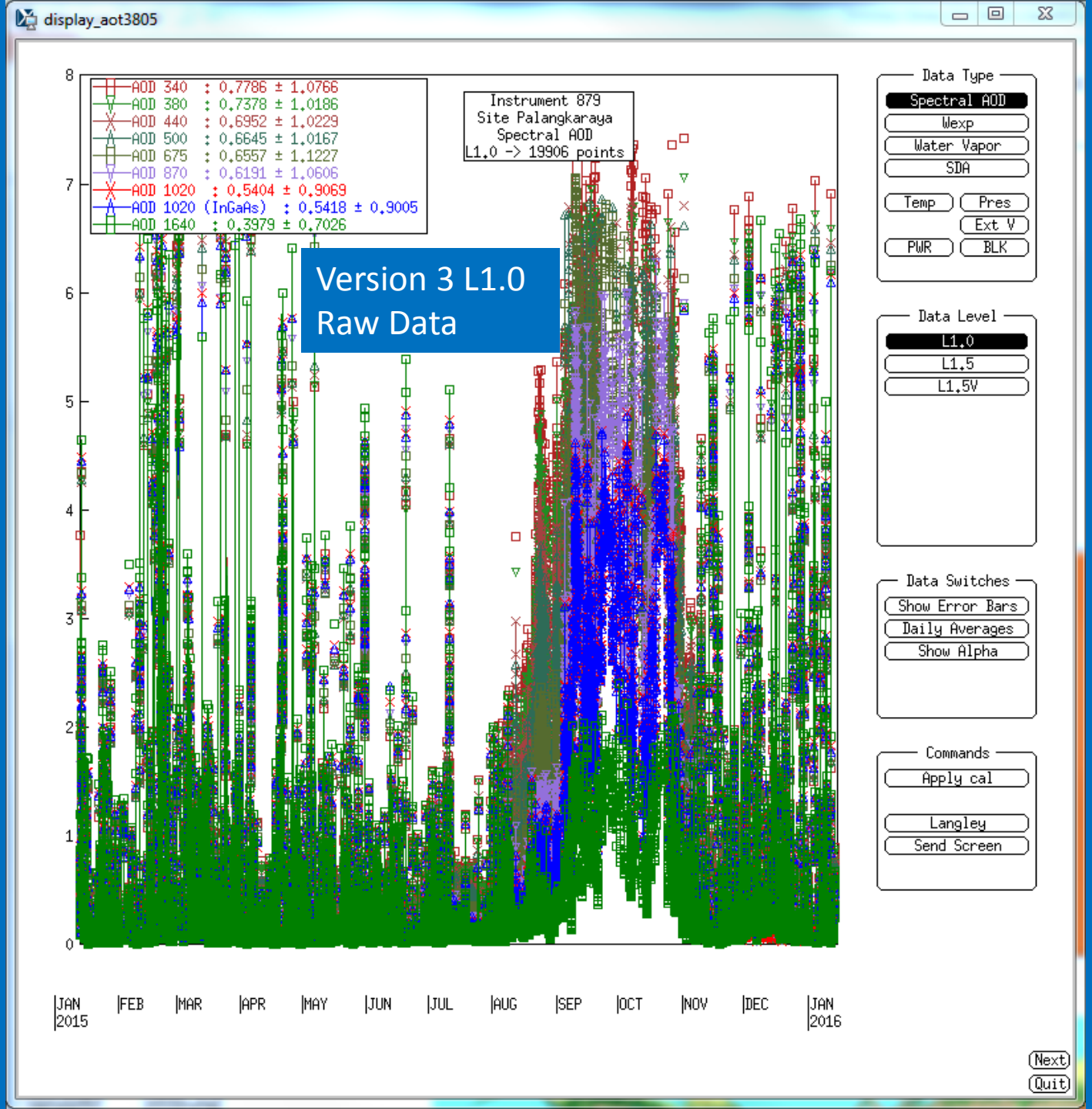
V3 removes more cirrus clouds

Indonesian Fires 2015 (Palangkaraya) – Current V2

Cloud cleared data (V2 Level 1.5)






display_aot3805
AOD 340 : 0.7786 ± 1.0766
AOD 380 : 0.7378 ± 1.0186
AOD 440 : 0.6952 ± 1.0229
AOD 500 : 0.6645 ± 1.0167
AOD 675 : 0.6557 ± 1.1227
AOD 870 : 0.6191 ± 1.0606
AOD 1020 : 0.5404 ± 0.9069
AOD 1020 (InGaAs) : 0.5418 ± 0.9005
AOD 1640 : 0.3979 ± 0.7026
Instrument 879
Site Palangkaraya
Spectral AOD
L1.0 -> 19906 points
Version 3 L1.0
Raw Data
Data Type
Spectral AOD
Wexp
Water Vapor
SDA
Temp
Pres
Ext V
PWR
BLK
Data Level
L1.0
L1.5
L1.5V
Data Switches
Show Error Bars
Daily Averages
Show Alpha
Commands
Apply cal
Langley
Send Screen
Next
Quit
JAN 2015
FEB
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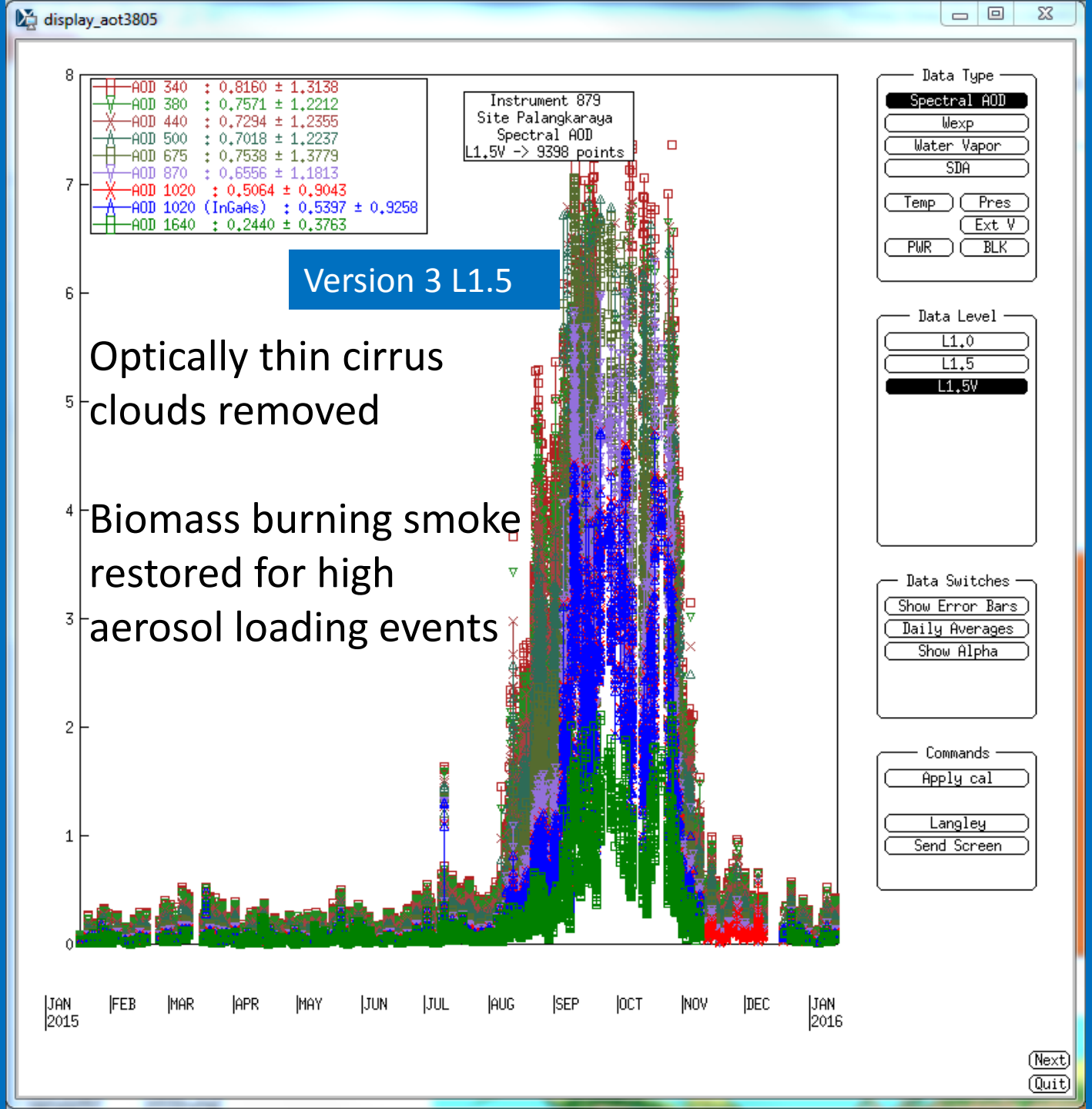
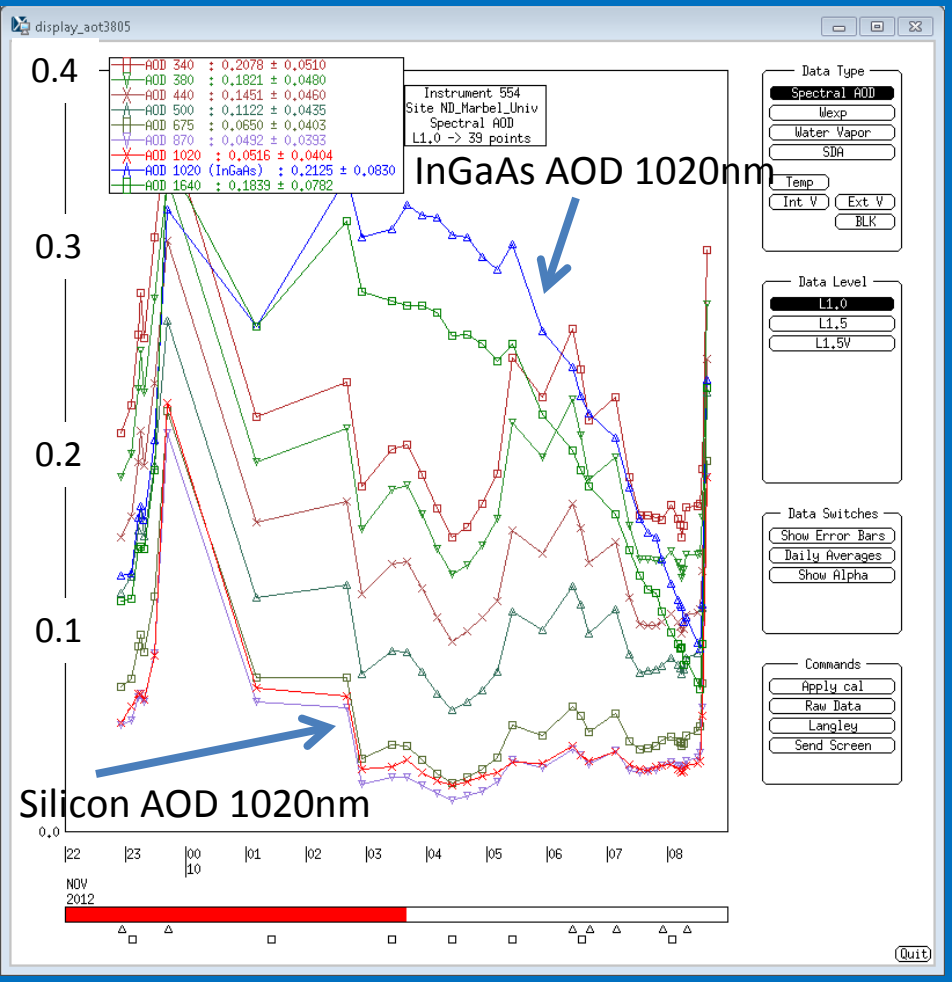
JAN 2016

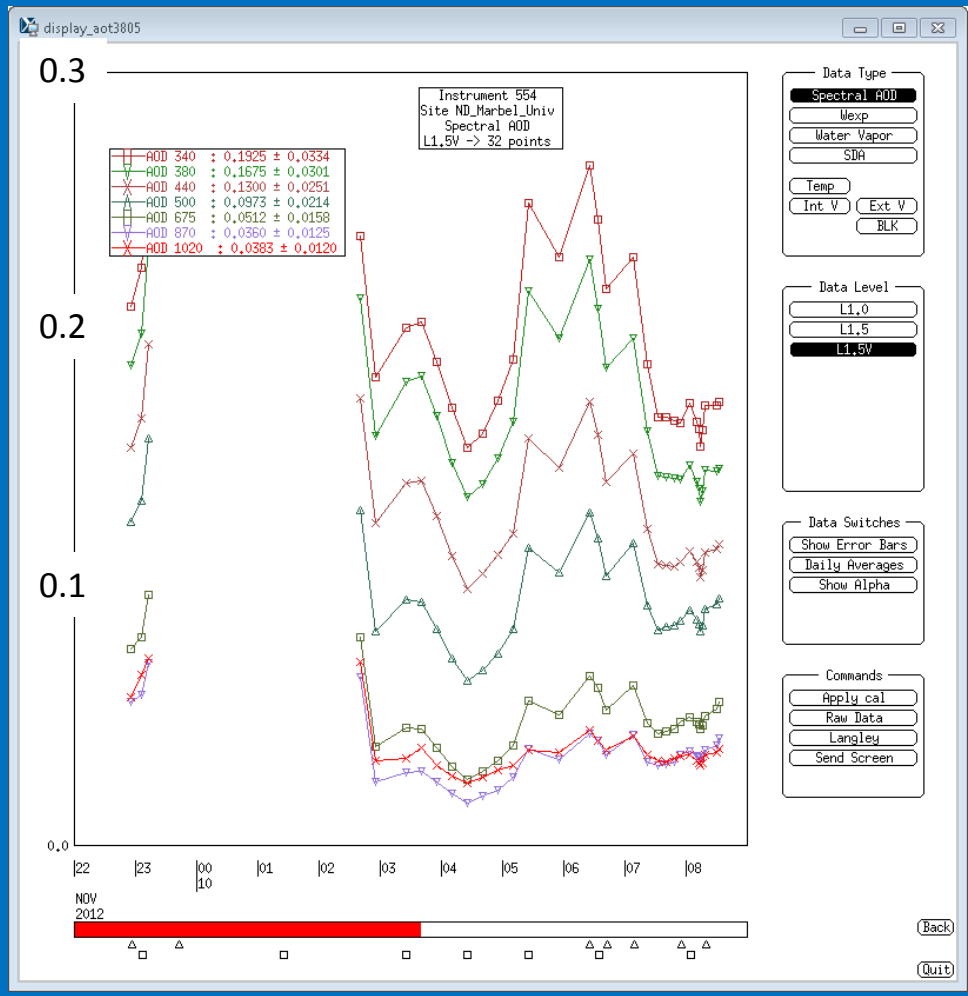

display_aot3805
AOD 340 : 0.8160 ± 1.3138
AOD 380 : 0.7571 ± 1.2212
AOD 440 : 0.7294 ± 1.2355
AOD 500 : 0.7018 ± 1.2237
AOD 675 : 0.7538 ± 1.3779
AOD 870 : 0.6556 ± 1.1813
AOD 1020 : 0.5064 ± 0.9043
AOD 1020 (InGaAs) : 0.5397 ± 0.9258
AOD 1640 : 0.2440 ± 0.3763
Instrument 879
Site Palangkaraya
Spectral AOD
L1.5V -> 9398 points
Version 3 L1.5
Optically thin cirrus clouds removed
Biomass burning smoke restored for high aerosol loading events
Data Type
Spectral AOD
Wexp
Water Vapor
SDA
Temp
Pres
Ext V
PWR
BLK
Data Level
L1.0
L1.5
L1.5V
Data Switches
Show Error Bars
Daily Averages
Show Alpha
Commands
Apply cal
Langley
Send Screen
Next
Quit
JAN 2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN 2016

Level 1.5 Quality Controls

- Raw Data Checks – sensor temperature, digital counts, clock shift, etc.
- Collimator consistency checks
- AOD diurnal dependence checks
- AOD spectral dependence checks
- Solar eclipse screening

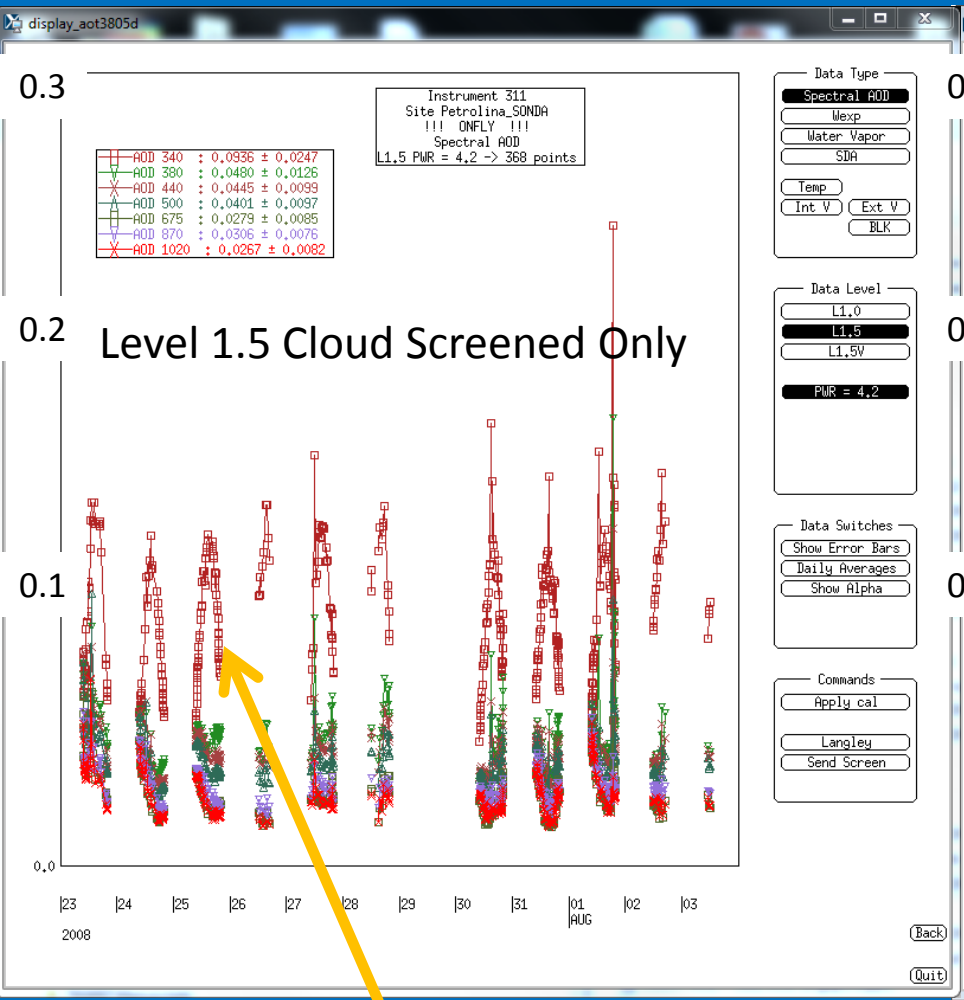
AERONET V3 L1.5: Collimator Consistency Check



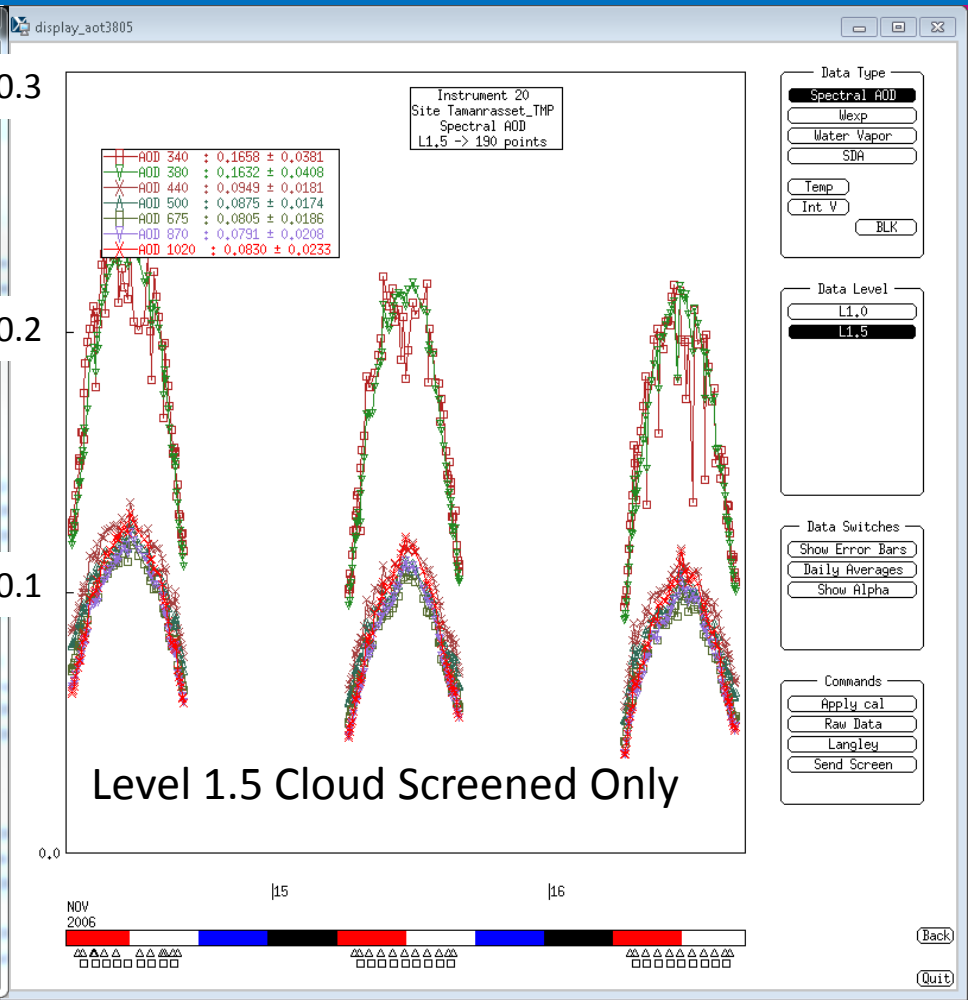


* InGaAs Channels Removed: 1020nm and 1640nm

AERONET V3 L1.5:
AOD Diurnal Dependence



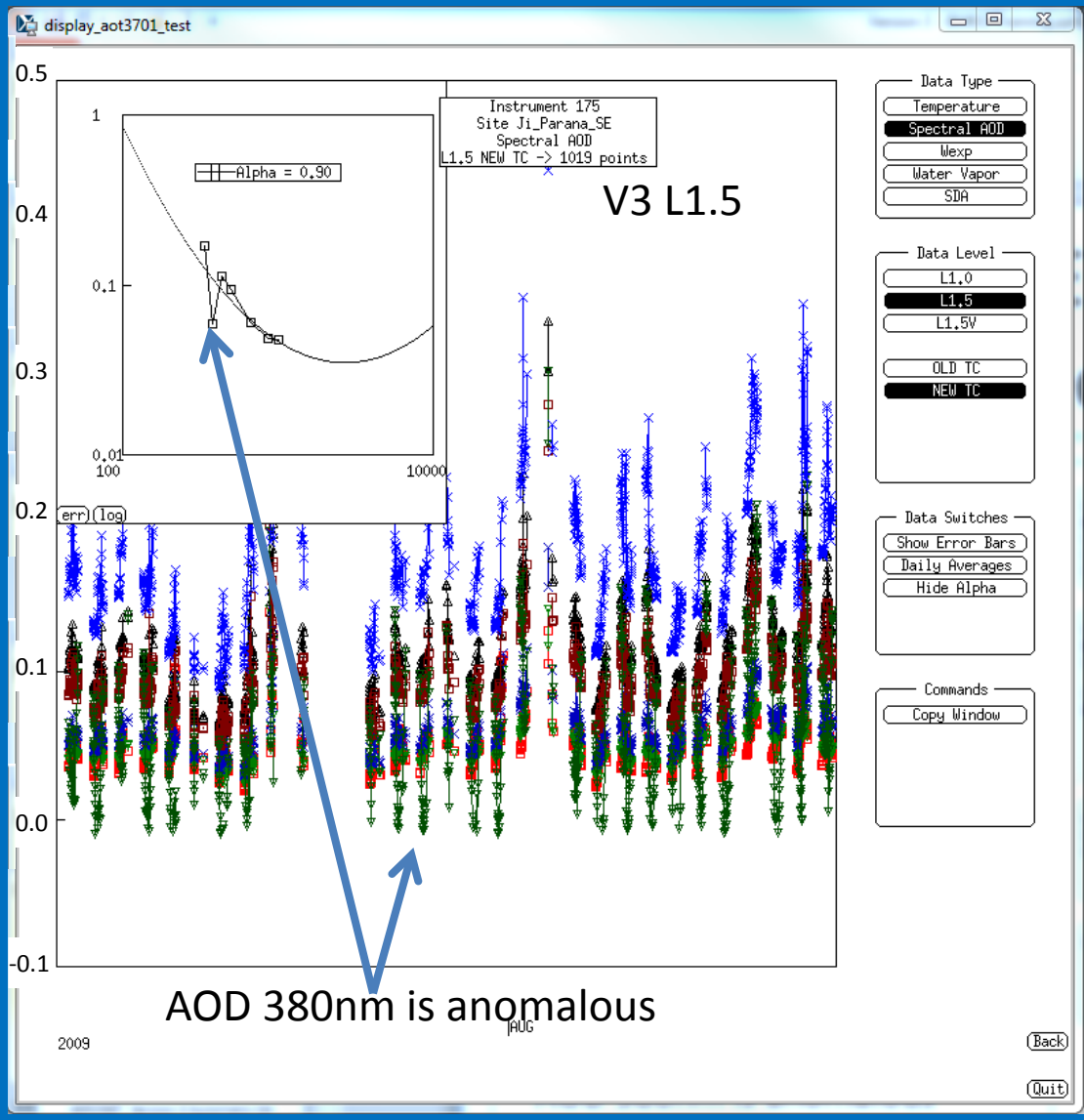
Only AOD 340nm data removed



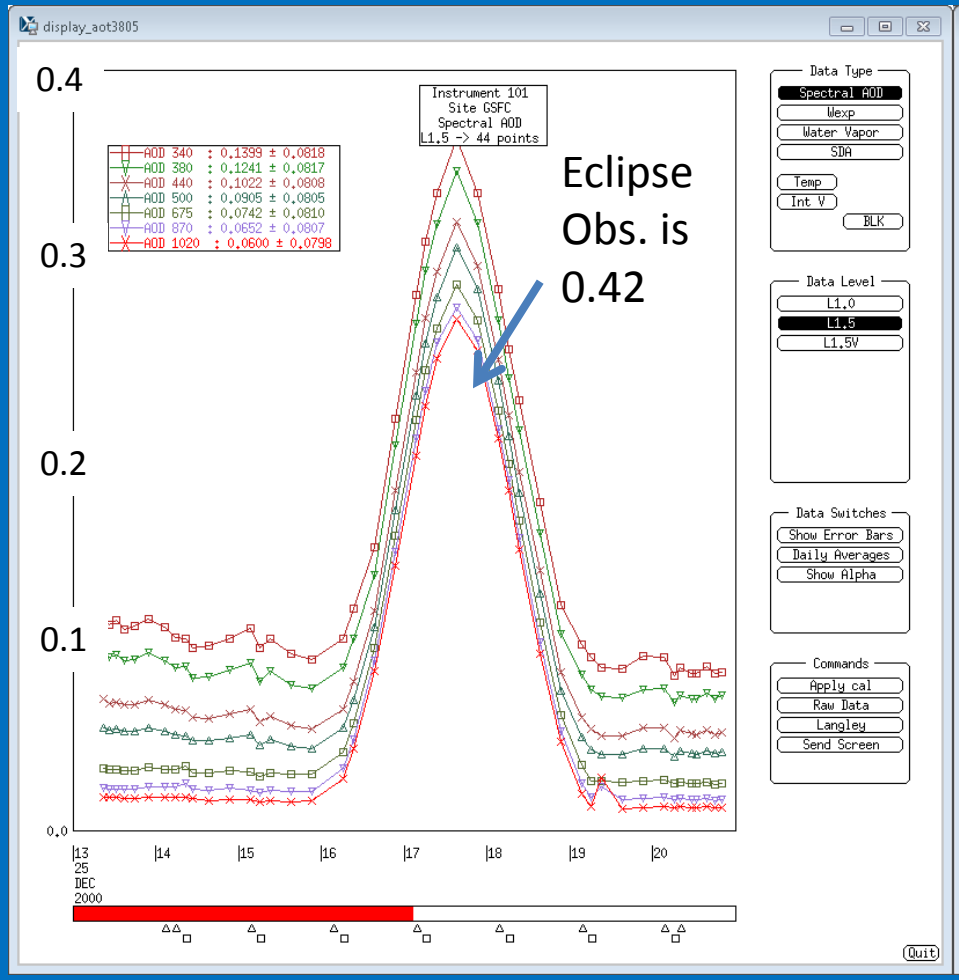
All spectral measurements removed

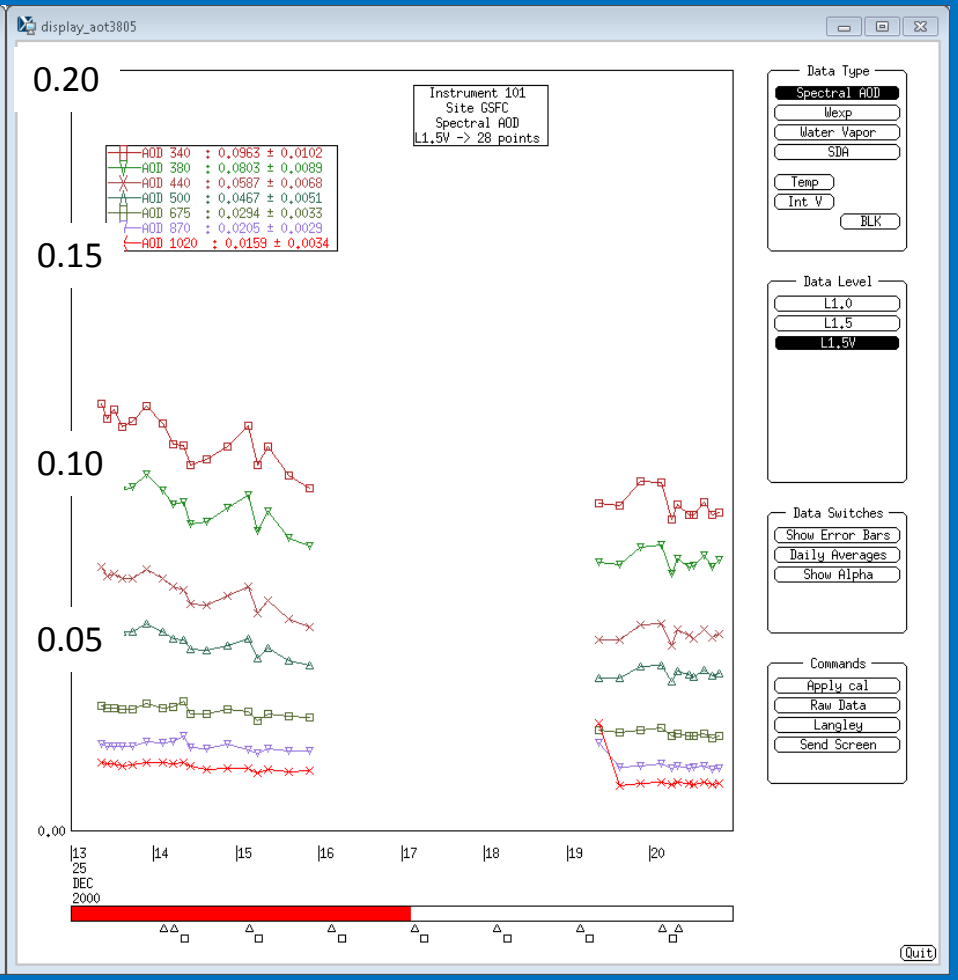
AERONET V3 L1.5: AOD Spectral Dependence

- Utilize mainly 1st or 2nd order fit
  - Number of wavelengths
  - AOD magnitude
- Employ iterative approach to remove outliers based on fit (fit-measurement)
- Combine with other screening techniques



AERONET Version 3 L1.5: Solar Eclipse Screening





* Uses NASA Eclipse database: http://eclipse.gsfc.nasa.gov
* AOD correction may be implemented

AERONET V3 Level 1.5

- New Level 1.5 AOD_{500nm} and $\alpha_{440\text{-}870nm}$ statistically very close to V2 Level 2.0
- Improperly filtered highly variable AODs (dominated by fine aerosols) may be restored in the V3 database
- Stable thin cirrus becomes less of an issue
  (less residual contamination)

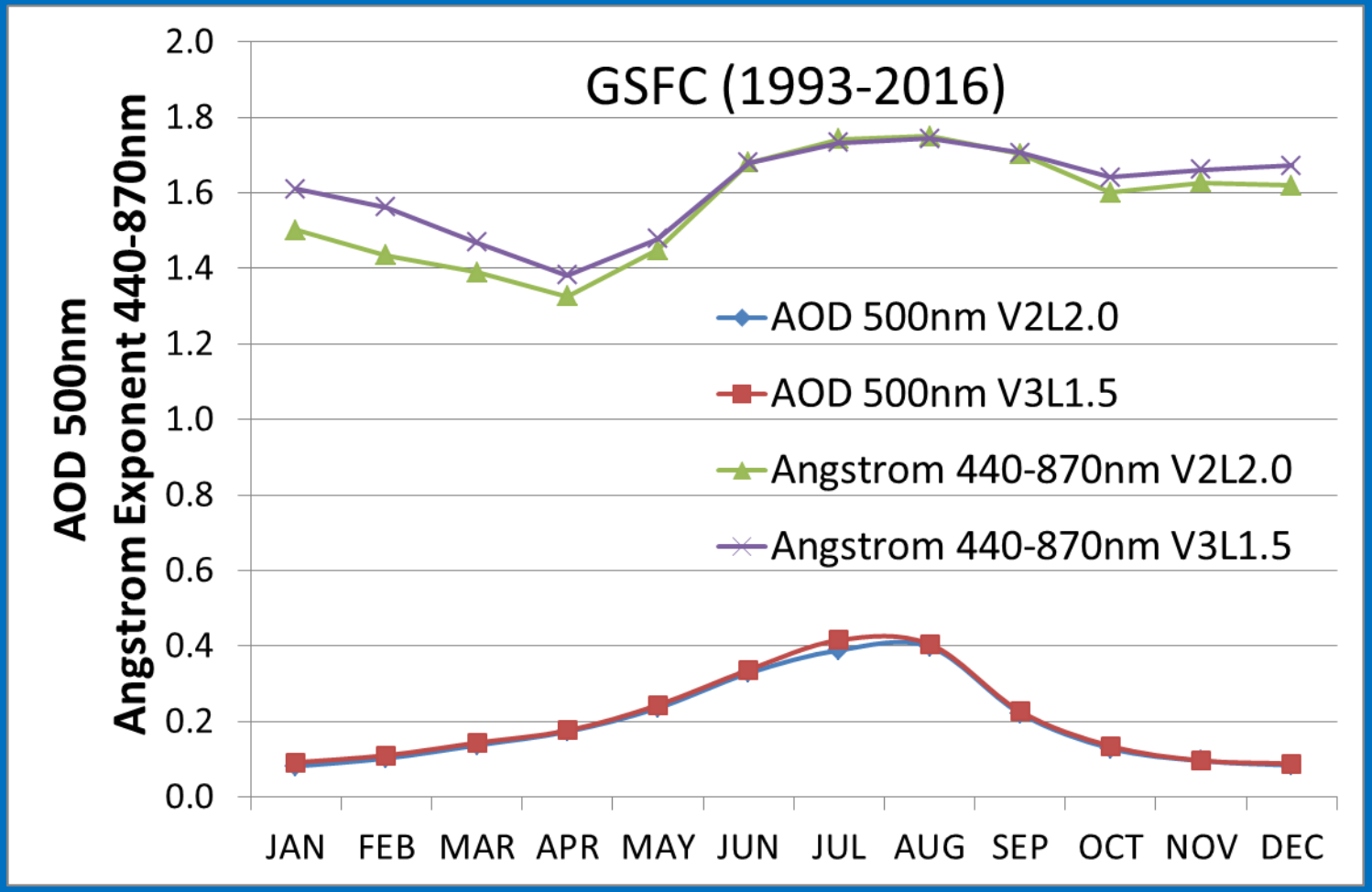
Nauru, #168, 2000-2005, 2010

Level	N	AOD	α
V2 L1.0	25579	0.23	0.31
V2 L1.5	13326	0.11	0.47
V2 L2.0	9371	0.08	0.54
V3 L1.5 CldScr	10385	0.07	0.48
V3 L1.5	9702	0.07	0.51

Singapore, #22, 2007-2011

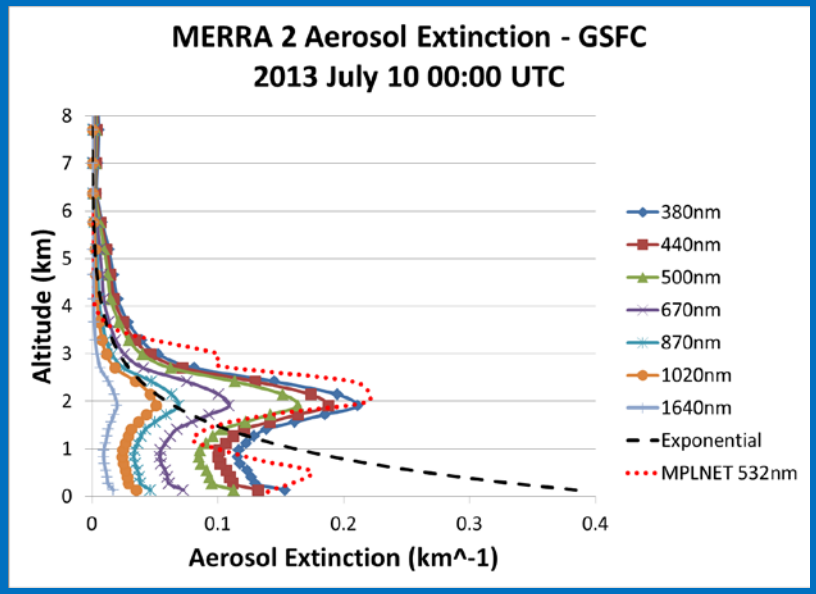
Level	N	AOD	α
V2 L1.0	25500	0.61	0.86
V2 L1.5	8680	0.46	1.03
V2 L2.0	6920	0.35	1.20
V3 L1.5 CldScr	6794	0.34	1.53
V3 L1.5	6534	0.35	1.52

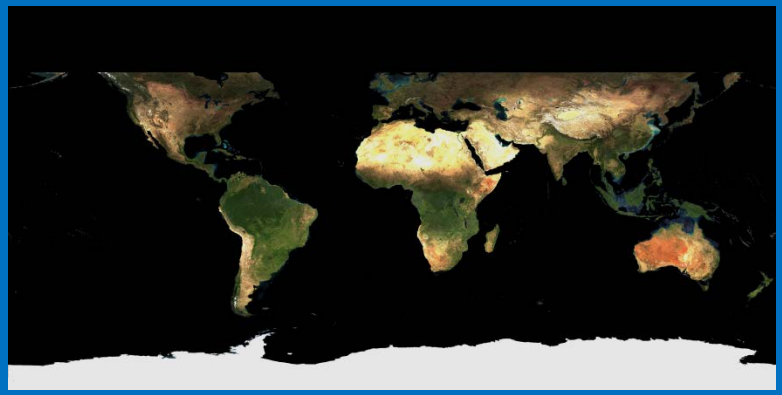
Climatology



AERONET Version 3 Update - Inversions

- Implement a vector radiative transfer code
  - radiation field in UV (e.g., 380 nm retrieval)
  - degree of linear depolarization
- Integrate spectral MERRA-2 aerosol extinction profiles to estimate aerosol vertical profile (Hybrid scans)
- Incorporate MODIS snow-free BRDF and snow BRDF to characterize surface albedo
- Provide lidar and depolarization ratio products
- Estimate uncertainties for each retrieval (e.g., random error plus biases due uncertainty in AOD and sky radiance calibration)
- Update inversion quality assurance criteria





MODIS NBAR January 1-8, 2013

Expected beta V3 release starting in July 2016

AERONET
New Instrumentation/Enhancements

- Greater control over instrument measurement scenarios (e.g., **Hybrid**)
- Additional capabilities such as SD card storage, GPS, USB, and Zigbee
- **Lunar measurements**
  - 1st to 3rd quarter lunar phase (waxing to waning gibbous)
  - Processing for lunar measurements (e.g., ROLO, Tom Stone)
- Development toward attachment for CO2 measurements (Emily Wilson)
- Synergism with MPLNET, PANDORA, and in situ measurements

Cimel Sun/Sky/Lunar Radiometer

Summary and Outlook

- Automatic quality controls perform objective assessments throughout the entire database and provide comparable results to manual screening

- Higher quality AOD data will be available in V3 NRT
  - Due to temperature characterization, improved cloud screening, and quality controls

- Level 2.0 will likely utilize the Level 1.5 automatic screening with minimal manual input

Summary and Outlook

- New Cimel T instrument control boxes will enhance capabilities (e.g., Hybrid, Lunar)

- V3 inversions will utilize new radiative transfer, ancillary data sets, and provide new products

- Hybrid scenario will improve temporal coverage of aerosol characteristics near satellite overpass times

➢ V3 AOD Level 1.0 and Level 1.5 NRT released

➢ V3 AOD Level 2.0 expected release: August 2016

➢ Beta V3 inversions expected release: July 2016

http://aeronet.gsfc.nasa.gov

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AERONET
AEROSOL ROBOTIC NETWORK

+ AEROSOL OPTICAL DEPTH | + AEROSOL INVERSIONS | + SOLAR FLUX | + OCEAN COLOR | + MARITIME AEROSOL

Web Site Feature | AERONET Data Synergy Tool - Access Earth Science data sets for AERONET sites

-Home

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+ AEROSOL/FLUX NETWORKS
+ CAMPAIGNS
+ COLLABORATORS
+ DATA
+ LOGISTICS
+ NASA PROJECTS
+ OPERATIONS
+ PUBLICATIONS
+ SITE INFORMATION
+ STAFF
+ SYSTEM DESCRIPTION

AERONET DATA ACCESS

DATA SYNERGY TOOL
+ Data Display

AEROSOL OPTICAL DEPTH (V3)
+ Data Display
+ Download Tool
+ Web Service

V3 NRT →

+ Data Display
+ Download Tool
+ Download All Sites
+ Climatology Tables
+ Climatology Maps
+ Data Availability (L2.0)

15 January 2014 - MODIS Rapid Response images are not available between January 2011 and mid-December 2013 (More Information)

MISSION

The AERONET (**AE**rosol **RO**botic **NET**work) program is a federation of ground-based remote sensing aerosol networks established by NASA and PHOTONS (PHOtométrie pour le Traitement Opérationnel de Normalisation Satellitaire; Univ. of Lille 1, CNES, and CNRS-INSU) and is greatly expanded by networks (e.g., RIMA, AeroSpan, AEROCAN, and CARSNET) and collaborators from national agencies, institutes, universities, individual scientists, and partners. The program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of instruments, calibration, processing and distribution.

AERONET collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Aerosol optical depth data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 (cloud-screened), and Level 2.0 (cloud-screened and quality-assured). Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality checks.

The processing algorithms have evolved from Version 1 to Version 2.0 (fully released in July 2006) and are available from the AERONET and PHOTONS web sites. Version 1 data may be downloaded from the web site through 2006 and thereafter upon special request. New AERONET products will be released as new measurement techniques and algorithms are adopted and validated by the AERONET research community. The AERONET web site also provides AERONET-related news, a description of research and operational activities, related Earth Science links, and an AERONET staff directory.

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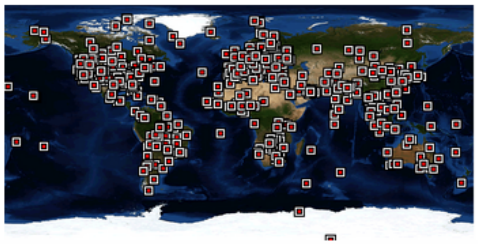

NEWS

10 May 2016

- The Distributed Regional Aerosol Gridded Observation Networks (DRAGON)-KORUS-AQ instrument deployment has been established in South Korea, Japan, and China from 1 April to 31 July 2016. The network will be strategically located to take advantage of KORUS-AQ in situ and airborne resources from mid-June 2016.
  + Read More